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PHYTOTOXICOLOGY SURVEY REPORT
GENERAL MOTORS FOUNDRY
ST. CATHARINES, 1991

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PHYTOTOXICOLOGY SURVEY REPORT
GENERAL MOTORS FOUNDRY - ST. CATHARINES, 1991

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Standards Development Branch

Phytotoxicology Survey Report General Motors Foundry, St. Catharines (1991)

ABSTRACT

This report summarizes the results of a Phytotoxicology survey conducted in August 1991. The General Motors Foundry was found to be a significant source of iron and fluoride emissions. Rural ULNs for both moss bags and tree foliage were exceeded at sites nearest the foundry. Although concentrations of other elements do not appear to be of concern, the foundry is also a marginal source of aluminum, and to a lesser extent, lead.

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1.0 Introduction

The General Motors Foundry in St. Catharines is the company's main facility in Canada for the manufacturing of automobile engines. The operation includes the recovery of metals from scrap as well as the manufacturing of automobile engines. The foundry covers approximately 150,000 m² (15 ha). It is situated in a predominantly rural area with open fields and wooded areas to the north, south and east. A vineyard exists to the northeast beyond the old Welland canal. To the west is the Welland canal with an industrial area of St. Catharines beyond and residential areas to the northwest and the southwest. The prevailing winds in this area are very strongly from the southwest.

In August of 1989, the Phytotoxicology Section conducted an assessment survey in the vicinity of the General Motors foundry and engine plant. The report³ indicated the foundry to be a significant source of iron and aluminium and showed there to be elevated concentrations of these two elements in maple foliage for as much as one kilometer downwind. Since this was the first such survey around the foundry, and since appropriate tree species could not be located in all desired locations, it was not possible to define the exact extent of elevated concentrations. The West Central Region of the MOEE requested that the survey be conducted again in 1991 in order to better define the extent of elevated concentrations and to establish that the pattern remained consistent over a time frame of more than one year.

2.0 Investigation Procedures

Since appropriate tree species could not be located in the areas directly downwind of the GM plant, it was decided to conduct a moss bag survey in addition to a maple foliage survey. Moss bag ion receptors are 6.5 cm by 15.5 cm bags made from polypropylene screening of mesh size 1.5 mm by 2.0 mm and containing 3.0 g of dry Sphagnum moss. The moss absorbs elements present in the air and can therefore be used to monitor atmospheric emissions. The moss bags are placed at a height of 2.5 to 3.5 m above the ground facing the suspected source of emissions.

On May 21, 1991, Marius Marsh and George Vasiloff of the Phytotoxicology Section placed moss bags at the eighteen locations shown in Figure 1. The moss bags were collected monthly and replaced with fresh moss bags. Exposed moss bags were allowed to dry and stored at 4° C until after the final collection in October. In total, there were five monthly moss bag exposure periods.

On August 27 and 28, 1991, samples of maple foliage were collected by Marius Marsh and Chengyeung Zhang of the Phytotoxicology Section from the sixteen locations indicated in Figure 1.

All samples were collected using standard Phytotoxicology sampling techniques¹. Samples were delivered to the Phytotoxicology Section sample processing laboratory in Toronto

where they were dried and ground before being submitted to the Laboratory Services Branch Trace Inorganics Laboratory for chemical analysis. The samples were then analyzed for lead (Pb), iron (Fe), molybdenum (Mo), manganese (Mn), aluminum (Al), fluorine (F), arsenic (As), antimony (Sb), selenium (Se) and sulphur (S). No analyses for organic contaminants were conducted.

Contour maps of elemental concentrations in foliage and in moss bags were produced using the graphics program "Surfer, Version 4.0". Contour maps were utilized where the maximum value for an elemental concentration was greater than twice the minimum value for either averaged moss bag concentrations or for foliage concentrations. Contour maps are statistical approximations of the spacial distribution of the element, and are useful for estimating the patterns of concentrations of the element. The contours produced by the program are affected by the spacial distribution of the sampling sites and by the program options used to generate the contours. The accuracy of the contours decreases with the density of the sampling sites. Contours in large areas without sampling sites such as near the edges of the maps should be interpreted with caution. The program options used for contour maps in this report were as follows;

Grid Interpolation Method : Kriging
Search Method : Normal
Search Radius : Map Width (5200 m)
No. of Nearest Points : 10
Grid size : 50 x 50 (75 m x 75 m)
Contour Smoothing : Yes
Tension factor : 2

3.0 Results

3.1 Results from Foliar Analyses

Table 1 shows the concentrations of elements in maple foliage in the vicinity of the foundry. Exceedences of the Upper Limit of Normal guidelines (ULN, see Appendix) occur in only four cases; they are, iron at Site 2, fluoride at Sites 2 and 11, and antimony at Site 8. The contour map of iron concentrations in foliage (Figure 2) shows a clear pattern of elevated concentrations in the vicinity of the foundry, particularly downwind from the foundry to the north-east, implicating the foundry as the major source of the iron. A similar pattern exists in the contour map for fluoride (Figure 3); however, a low result at Site 3 complicates the interpretation of the fluoride results. Since only one antimony result was above the analytical detection limit, foliar antimony concentrations were not mapped. The high antimony result at Site 8 resulted from only one of the triplicate samples being above the detection limit. The mean used in the table is therefore not a reliable indication of the site, and is unlikely to have resulted from any activities at the foundry.

Although lead concentrations in foliage are considerably lower than the ULN, the contour map (Figure 4) shows a pattern of distribution very similar to that of iron and indicates the foundry to be a minor source of lead. The concentrations of lead in foliage are environmentally inconsequential (i.e. they are not phytotoxic), although they are an indicator of marginal lead emissions from G.M. Similarly, although mapping of foliar aluminum concentrations (Figure 5) indicates the foundry to be a potential source of aluminum, foliar concentrations are below levels of concern. Similar to fluoride, the result for aluminum at Site 3 is considerably lower than at Sites 2 and 11, thus distorting the contours.

Manganese concentrations in foliage tend to be low in the immediate vicinity of the foundry where iron concentrations are high. This pattern can be seen on Figure 6, and is possibly attributable to displacement of manganese by the more strongly held iron.

There was insufficient variation in concentrations of molybdenum, arsenic, selenium and sulphur to produce meaningful contour maps.

Comparison of the data for this survey with that of the previous, 1989 survey (MOE. 1990), indicates that for iron at a given site, there was a tendency for lower concentrations in 1991 than in 1989. For example, the maximum foliar iron concentration was 803 ug/g at Site 2 in 1989, but only 610 ug/g in 1991, again at Site 2.

Table 1. Elemental Concentrations (ug/g dry weight) in Foliage in the Vicinity of General Motors Foundry, St. Catharines, Ont. Aug 27, 1991.

Site	Species	Pb	Fe	Mn	Al	F	S (%)	Mo	As	Sb	Se
1	S	1T	240	190	92	7.5	0.14	0.4T	DL	DL	0.2T
2	S	4.8	610	28	220	26	0.16	0.43T	0.38T	DL	0.36T
3	S	2.1T	300	64	110	8.6	0.12	0.3T	DL	DL	DL
4	S	2.3T	320	39	88	6.8	0.12	0.3T	DL	DL	DL
5	S	1.6T	240	110	61	4.3	0.14	DL	DL	DL	DL
6	S	2.2T	320	32	250	7.5	0.11	DL	0.22T	DL	DL
7	S	0.88T	100	17	50	3.9	0.13	DL	DL	DL	DL
8	S	2.8	200	18	120	7.4	0.18	0.33T	DL	0.5T	DL
9	S	1.8T	210	180	99	9	0.17	DL	DL	DL	DL
11	S	2.4T	340	42	200	16	0.21	DL	DL	DL	DL
12	S	DL	110	23	57	6	0.14	DL	DL	DL	DL
13	S	0.72T	99	65	49	5.4	0.15	DL	DL	DL	DL
14	S	0.92T	190	173	117	6.5	0.19	0.33T	DL	DL	DL
15	S	0.78T	133	46	59	5.6	0.17	DL	DL	DL	DL
25	S	0.9T	130	110	81	6.6	0.14	DL	DL	DL	DL
26	M	0.5T	170	28	110	4.9	0.17	0.3T	DL	DL	DL
ULN	NG	30	500	NG	500	15	0.4	1.5	0.5T	0.3T	0.5T

ULN Upper Limit of Normal for rural foliage (unwashed). See Appendix for explanation.

DL - result was at or below the analytical detection limit

T - a measureable trace amount, interpret with caution.

NG - no guideline currently exists

NR - no result

S - Silver Maple

M - Manitoba Maple

3.2 Results from Moss Bag Analyses

Tables 2 to 6 show monthly elemental concentrations in moss bags located in the vicinity of the General Motors foundry. Table 7 shows the average of these results for each site over the collection period of May to October. A large number of exceedences of the ULN for sulphur occurred during this survey. These exceedences are not linked to the foundry in that they occur even at the remote sites.

The ULNs for iron, fluoride, and selenium are often exceeded at Sites 16, 9, and 11, those closest to and downwind of the foundry. Contour maps for concentrations of iron, fluoride, and selenium are shown in Figures 7, 8, and 9 respectively. These figures all show increases in elemental concentrations near the foundry, largely to the north and north-northeast. They do not show elevated concentrations to the east and east northeast beyond the area immediately adjacent to the property. Although these results clearly indicate the foundry to be a source of iron and fluoride emissions, the results are less clear for selenium. Selenium was depleted from the moss during the exposure periods, and the concentrations even at the sites nearest the foundry do not reach concentrations in the fresh (unexposed) moss. This means that the higher concentrations near the foundry could result from either atmospheric deposition from the source, or from other factors linked to foundry emissions which reduce the rate of loss of selenium from the moss bags, such as complexation of selenium with other contaminants. Selenite is known to complex readily with iron and form a compound less soluble than the original selenite.

Concentrations of lead and aluminum in moss bags do not exhibit the same relative degree of variation as they do in foliage; however, the patterns displayed in the contour maps (Figures 10, and 11) are similar. In contrast, the contour pattern for manganese in moss bags (Figure 12) is considerably different than that in tree foliage (Figure 6). Manganese was not depleted in moss bags when other elements are elevated in concentration as it is in foliage.

Table 8 shows monthly elemental concentrations in moss bags averaged across all sites. The highest concentrations of Fe, Al, F, S, As, Sb, and Se, occurred in October. Foliar sampling would not reflect these higher ambient concentrations.

Table 2. Elemental Concentrations (ug/g dry weight) in Moss Bags Collected on June 25, 1991 (34 day exposure) in the Vicinity of General Motors Foundry, St. Catharines.

Site	Pb	Fe	Mn	Al	F	Mo	S (%)	As	Sb	Se
4	29	1000	260	760	14	0.4T	0.1	0.66T	0.24T	0.47T
8	23	720	250	640	8.5	DL	0.095	0.63T	DL	0.44T
9	37	1600	260	920	33	0.9T	NR	0.79T	0.32T	0.53T
11	29	1400	280	840	83	DL	0.16	0.81T	DL	0.51T
12	28	810	250	580	7.2	DL	0.074	0.52T	0.25T	0.36T
13	23	650	240	620	7.4	DL	0.086	0.6T	0.25T	0.39T
14	27	820	250	730	10	DL	0.091	0.63T	0.23T	0.4T
15	23	660	260	610	8.5	DL	0.09	0.53T	0.22T	0.4T
16	35	1700	270	880	28	0.3T	0.11	0.77T	0.34T	0.53T
17	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
18	31	1200	250	780	19	DL	0.12	0.72T	0.27T	0.58T
19	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
20	28	730	250	630	13	DL	0.098	0.61T	DL	0.35T
21	21	730	230	620	14	DL	0.1	0.6T	DL	0.39T
22	23	710	250	660	8.1	DL	0.11	0.58T	DL	0.48T
23	25	870	250	700	12	0.4T	0.098	0.59T	DL	0.45T
24	23	980	240	820	19	DL	0.13	0.78T	0.22T	0.5T
25	21	740	240	690	12	0.3T	0.1	0.55T	DL	0.38T
ULN	35	1700	NG	1700	45	NG	0.1	1	NG	0.6

ULN Upper Limit of Normal for moss bags (rural). See Appendix for explanation.

DL - result was at or below the analytical detection limit

T - a measureable trace amount, interpret with caution.

NG - no guideline currently exists

NR - no result

Table 3. Elemental Concentrations (ug/g dry) in Moss Bags Collected on July 24, 1991 (29 day exposure) in the Vicinity of General Motors Foundry, St. Catharines.

Site	Pb	Fe	Mn	Al	F	Mo	S (%)	As	Sb	Se
4	18	1000	230	670	13	DL	0.1	0.52	0.2	0.46
8	19	810	240	700	8.5	0.3T	0.091	0.58	0.24	0.39
9	18	1500	280	920	27	0.3T	0.13	0.55	0.3	0.6
11	24	1200	230	830	35	0.24T	0.11	0.64	0.37	0.41
12	20	700	250	630	9.3	DL	0.11	0.53	0.2	0.43
13	19	790	240	630	7.3	0.3T	0.093	0.59	0.23	0.43
14	18	750	220	590	9	DL	0.099	0.63	0.23	0.48
15	16	680	270	560	6	DL	0.09	0.58	0.2	0.42
16	24	1600	270	930	25	0.3T	NR	0.54	0.4	0.64
17	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
18	18	1000	230	670	13	0.25T	0.11	0.58	0.22	0.5
19	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
20	18	680	240	560	8.1	DL	0.091	0.49	0.21	0.41
21	16	980	260	750	14	DL	0.12	0.57	0.2	0.52
22	17	780	230	630	9.8	DL	0.12	0.57	0.23	0.51
23	21	1200	270	910	24	0.37T	NR	0.72	0.47	0.47
24	26	3900 ¹	340	1500	24	0.8T	0.13	0.67	0.36	0.48
25	15	980	300	790	19	DL	NR	0.54	0.29	0.48
ULN	35	1700	NG	1700	45	NG	0.1	1	NG	0.6T

ULN Upper Limit of Normal for moss bags (rural). See Appendix for explanation.

¹ This moss bag had been removed when hydro pole was replaced earlier on day of retrieval. Contamination may have resulted.

DL - result was at or below the analytical detection limit

T - a measureable trace amount, interpret with caution.

NG - no guideline currently exists

NR - no result

Table 4. Elemental Concentrations (ug/g dry weight) in Moss Bags Collected on Aug. 27, 1991 (34 day exposure) in the Vicinity of General Motors Foundry, St. Catharines.

Site	Pb	Fe	Mn	Al	F	Mo	S(%)	As	Sb	Se
4	18	1200	240	720	14	0.4T	0.14	0.57T	DL	0.7T
8	19	880	250	640	11	DL	0.1	0.52T	DL	0.5T
9	20	1200	220	800	34	DL	0.12	0.49T	DL	0.52T
11	19	1600	290	940	59	DL	0.14	0.68T	DL	0.54T
12	18	740	230	590	11	DL	0.1	0.56T	DL	0.4T
13	NR	NR	NR	NR	9.1	NR	0.082	0.5T	DL	0.42T
14	19	890	270	650	16	DL	NR	0.54T	DL	0.44T
15	21	770	220	580	14	DL	0.092	0.56T	0.21T	0.51T
16	26	1500	240	800	35	0.3T	0.086	0.64T	0.24T	0.56T
17	18	830	230	640	11	DL	0.09	0.43T	DL	0.42T
18	17	1200	280	780	10	DL	0.1	0.47T	DL	0.46T
19	21	750	210	660	14	DL	0.088	0.61T	DL	0.41T
20	16	790	240	610	7.1	DL	0.098	0.49T	DL	0.39T
21	24	870	220	650	18	DL	0.12	0.67T	0.23T	0.46T
22	19	760	240	610	11	0.3T	0.087	0.53T	0.22T	0.43T
23	22	930	220	630	15	DL	0.096	0.62T	0.21T	0.39T
24	22	1100	220	730	18	DL	0.12	0.78T	DL	0.47T
25	22	760	210	590	14	DL	0.11	0.67T	0.22T	0.43T
ULN	35	1700	NG	1700	45	NG	0.1	1	NG	0.6T

ULN - Upper Limit of Normal for moss bags (rural). See Appendix for explanation.

DL - result was at or below the analytical detection limit

T - a measureable trace amount, interpret with caution.

NG - no guideline currently exists

NR - no result

Table 5. Elemental Concentrations (ug/g dry weight) in Moss Bags Collected on Sept. 25, 1991 (29 day exposure) in the Vicinity of General Motors Foundry, St. Catharines.

Site	Pb	Fe	Mn	Al	F	Mo	S (%)	As	Sb	Se
4	29	1100	230	790	21	DL	0.11	0.67T	0.3T	0.59T
8	28	940	210	670	12	0.23T	0.081	0.77T	0.24T	0.4T
9	37	2100	240	1100	45	0.45T	0.096	0.94T	0.49T	0.88T
11	33	1500	250	850	63	0.39T	0.083	0.82T	0.31T	0.38T
12	27	950	230	810	15	0.23T	NR	0.76T	0.23T	0.4T
13	25	900	220	730	15	DL	0.072	0.74T	0.24T	0.38T
14	27	1100	220	890	16	0.24T	0.082	0.9T	0.23T	0.32T
15	29	990	220	850	16	DL	0.075	0.74T	DL	0.35T
16	44	2500	240	1100	54	0.53T	0.079	0.88T	0.39T	0.85T
17	32	1300	220	780	19	0.23T	0.07	0.82T	0.39T	0.47T
18	26	1600	230	910	23	DL	0.1	0.95T	0.45T	0.63T
19	25	890	210	690	17	DL	0.096	0.7T	0.26T	0.37T
20	27	870	220	760	13	0.23T	NR	0.69T	0.22T	0.4T
21	32	1200	210	820	16	0.22T	0.078	0.76T	0.27T	0.43T
22	33	1000	200	690	15	DL	0.079	0.86T	0.23T	0.44T
23	30	1200	220	850	19	0.26T	0.084	0.8T	0.22T	0.42T
24	31	1200	230	780	23	0.25T	0.095	0.82T	0.21T	0.47T
25	26	930	210	720	17	0.23T	0.095	0.7T	0.23T	0.37T
ULN	35	1700	NG	1700	45	NG	0.1	1	NG	0.6T

ULN - Upper Limit of Normal for moss bags (rural). See Appendix for explanation.

DL - result was at or below the analytical detection limit

T - a measureable trace amount, interpret with caution.

NG - no guideline currently exists

NR - no result

Table 6. Elemental Concentrations (ug/g dry weight) in Moss Bags Collected on Oct. 25, 1991 (30 day exposure) in the Vicinity of General Motors Foundry, St. Catharines.

Site	Pb	Fe	Mn	Al	F	Mo	S (%)	As	Sb	Se
4	25	900	230	790	19	DL	0.12	0.79T	0.28T	0.36T
8	28	800	230	660	16	DL	0.11	0.8T	DL	0.37T
9	33	2200	260	1300	79	0.39T	0.14	0.88T	0.44T	0.93T
11	30	1200	230	770	39	0.26T	0.13	0.66T	0.24T	0.6T
12	24	850	220	690	20	DL	0.11	0.75T	0.23T	0.36T
13	25	910	210	750	20	DL	NR	0.72T	0.26T	0.42T
14	25	910	220	740	29	0.22T	0.11	0.88T	DL	0.47T
15	28	800	220	740	16	DL	0.094	0.63T	DL	0.32T
16	36	2800	270	1600	100	0.51T	0.13	0.97T	0.51T	0.96T
17	28	1200	230	770	32	0.26T	0.11	0.76T	0.28T	0.46T
18	30	1200	230	950	28	0.96T	0.12	0.79T	0.28T	0.4T
19	25	910	210	720	22	DL	0.12	0.72T	0.29T	0.32T
20	26	850	200	770	16	DL	0.1	0.52T	0.29T	0.31T
21	30	1300	240	940	40	DL	0.14	1	0.32T	0.64T
22	25	1100	220	900	31	0.23T	0.12	0.89T	0.24T	0.52T
23	29	1400	250	1000	37	DL	0.17	1.1	0.28T	0.46T
24	33	1100	220	860	31	DL	0.13	0.84T	0.29T	0.47T
25	26	NR*	260	840	26	0.22T	NR	2.1	0.32T	0.46T
ULN ¹	35	1700	NG	1700	45	NG	0.1	1	NG	0.6T

1. Upper Limit of Normal for moss bags (rural). See Appendix 5.1 for explanation.

DL - result was at or below the analytical detection limit

T - a measurable trace amount, interpret with caution.

NG - no guideline currently exists

NR - no result

NR* - Repeat analysis indicated extremely high variability. The results (4400 and 8400 ug/g) are not reliable

Table 7. Average Elemental Concentrations (ug/g) in Moss Bags between May 21 and Oct. 25, 1991 (Average 31 day exposure) in the Vicinity of General Motors Foundry, St. Catharines.

Site	Pb	Fe	Mn	Al	F	Mo	S (%)	As	Sb	Se
4	23.8	1040	238	746	16.2	0.28T	0.114	0.64T	0.24T	0.52T
8	23.4	830	236	662	11.2	0.23T	0.095	0.66T	0.22T	0.42T
9	29	1720	252	1008	43.6	0.45T	0.122	0.73T	0.35T	0.69T
11	27.8	1425	263	850	61	0.26T	0.129	0.72T	0.26T	0.49T
12	23.4	812	236	660	12.5	0.21T	0.099	0.62T	0.22T	0.39T
13	23	813	228	683	11.8	0.23T	0.083	0.63T	0.24T	0.41T
14	23.2	894	236	720	16	0.21T	0.095	0.72T	0.22T	0.42T
15	23.4	780	238	668	12.1	DL	0.088	0.61T	0.21T	0.40T
16	33	2020	258	1062	48.4	0.39T	0.101	0.76T	0.37T	0.71T
17	26	1110	227	730	20.7	0.23T	0.09	0.67T	0.29T	0.45T
18	25.6	1280	244	850	23	0.36T	0.11	0.70T	0.28T	0.51T
19	23.7	850	210	690	17.7	DL	0.101	0.68T	0.25T	0.37T
20	23	784	230	666	11.4	DL	0.097	0.56T	0.22T	0.37
21	24.6	1016	232	756	20.4	DL	0.112	0.72T	0.24T	0.49T
22	23.4	870	228	698	15	0.23T	0.103	0.68T	0.22T	0.48T
23	25.4	1120	242	818	21.4	0.29T	0.112	0.77T	0.28T	0.44T
24	27	1656	250	938	23	0.33T	0.121	0.78T	0.26T	0.48T
25	22	853	244	726	17.6	0.23T	0.102	0.91T	0.25T	0.42T
ULN	35	1700	NG	1700	45	NG	0.1	1	NG	0.6T
Fresh Moss	22.5	869	140	NR	12.5	0.51	0.07	0.968	0.323	1.52

ULN - Upper Limit of Normal for moss bags (rural). See Appendix for explanation.

DL - result was at or below the analytical detection limit

T - a measurable trace amount, interpret with caution.

NG - no guideline currently exists

NR - no result

Table 8. Average (all sites) Monthly Elemental Concentrations (ug/g dry weight) in Moss Bags in the Vicinity of General Motors Foundry, St. Catharines.

Month	Pb	Fe	Mn	Al	F	Mo	S (%)	As	Sb	Se
June	26.6	958	252	718	18.5	0.28T	0.104	0.65T	0.23T	0.45T
July	19.3	1170	258	773	15.9	0.28T	0.107	0.58T	0.27T	0.48T
Aug	20.1	986	237	684	17.8	0.22T	0.104	0.57T	0.21T	0.47T
Sept	30.1	1237	223	822	23.3	0.26T	0.086	0.80T	0.28T	0.47T
Oct	28.1	1602	231	877	33.4	0.28T	0.122	0.88T	0.29T	0.49T
Average	25.0	1188	238	774	22.4	0.26T	0.104	0.70T	0.26T	0.47T

4.0 Conclusions

The General Motors foundry is a significant source of iron and fluoride emissions that results in exceedences of rural Upper Limit of Normal guidelines in the immediate vicinity of the foundry. The foundry is also a source of aluminum and to a lesser extent, lead, although concentrations of these elements do not exceed the rural ULNs for either moss bags or foliage. In addition, the data indicate that the foundry may be emitting selenium; however, the higher selenium concentrations in moss bags near the foundry could be a result of greater retention in the moss due to complexation of selenium in the moss with contaminants from the foundry, most notably iron.

Elevated concentrations of iron and fluoride extend roughly one kilometer downwind of the factory to the north-northeast. Results from the use of moss bags in this survey in areas where suitable tree species could not be found, indicated that the area of elevated concentrations does not extend significantly to the east or east-northeast. In fact, the 1991 moss bag data show that the area to the east and east-northeast is receiving less iron, fluoride, and aluminum than the foliar sampling alone indicates. This better defines the emissions impact zone and alleviates a potential concern raised as a result of the 1989 foliar survey.

5.0 References

1. Ontario Ministry of the Environment, 1983. Field Investigation Manual. Phytotoxicology Section, Air Resources Branch; Technical Support Sections - NE and NW Regions.
2. Ontario Ministry of the Environment, 1989. Ontario Ministry of the Environment "Upper Limit of Normal Contaminant Guidelines for Phytotoxicology Samples". Phytotoxicology

3. Ontario Ministry of the Environment, 1990. Phytotoxicology Section Investigation in the Vicinity of General Motors Foundry, St. Catharines, Ontario, August 15, 1989.

Appendix

Derivation and Significance of the MOE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines.

The MOE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (reference: Ontario Ministry of the Environment 1992, *Phytotoxicology Field Investigation Manual*). Chemical analyses were conducted by the MOE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.

Figure 1: Locations of Pollar and Moss Bag Sampling Sites in the Vicinity of General Motors, St. Catharines, 1991.

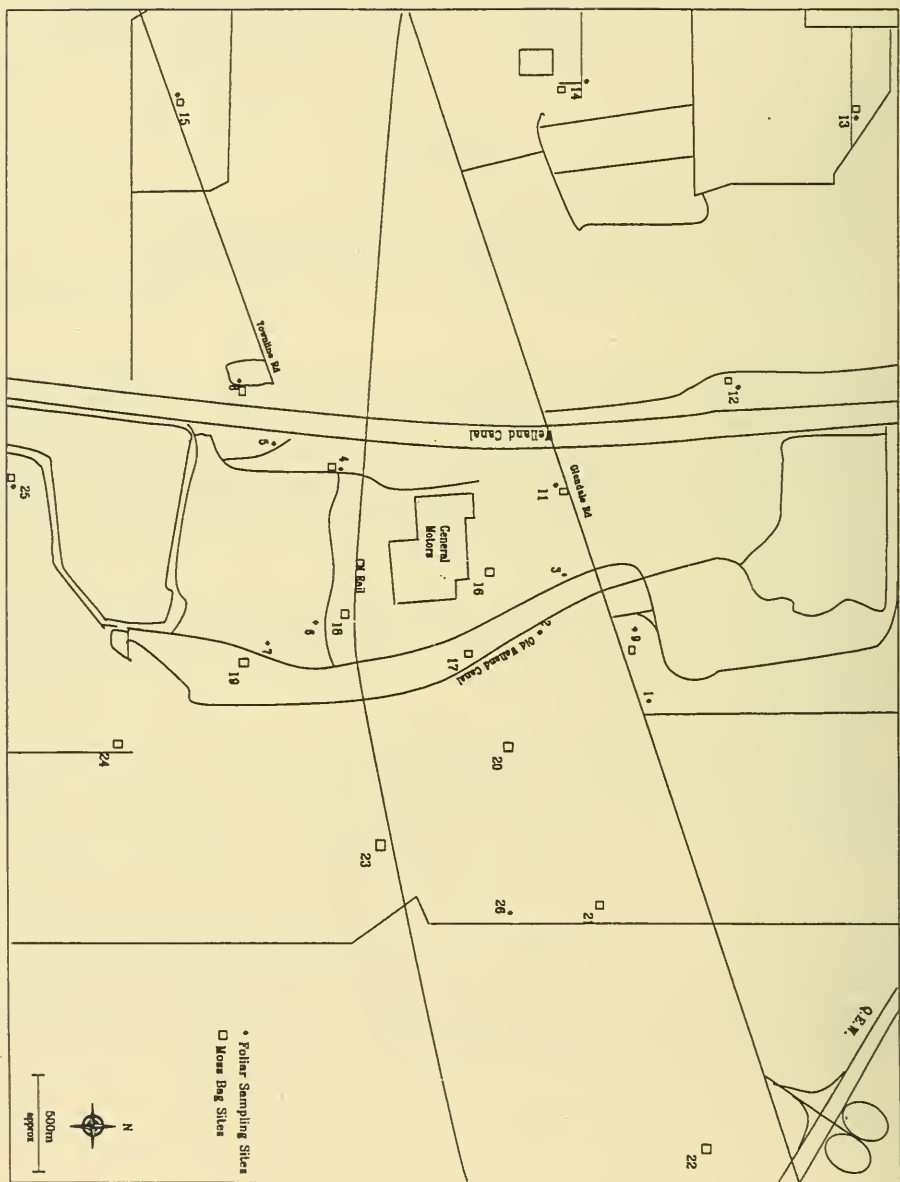


Figure 2: Contour Map of Iron Concentrations (ug/g) in Maple Foliage in the Vicinity of the G.M. Foundry, St. Catharines, August 27, 1991.

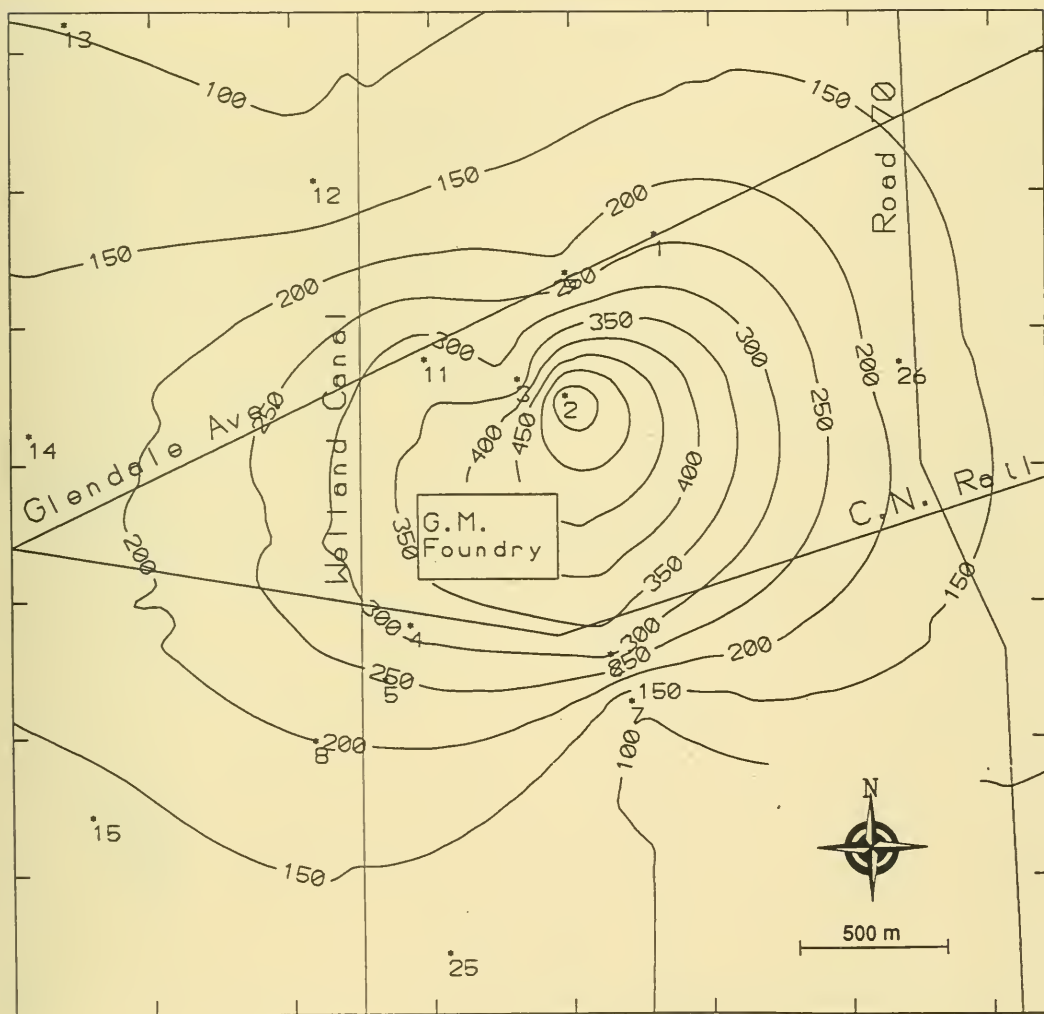


Figure 3: Contour Map of Fluoride Concentrations (ug/g) in Maple Foliage in the Vicinity of the G.M. Foundry, St. Catharines, August 27, 1991.

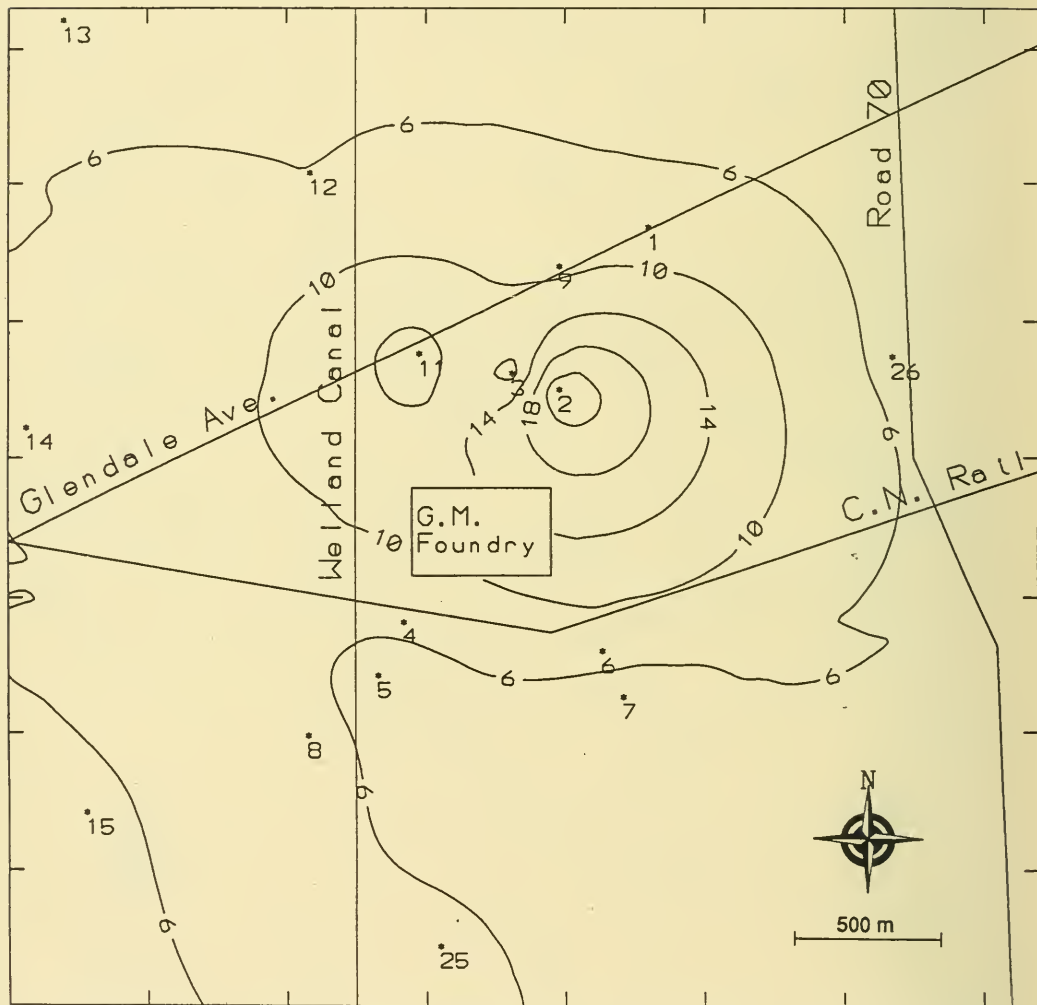


Figure 4: Contour Map of Lead Concentrations (ug/g) in Maple Foliage in the Vicinity of the G.M. Foundry, St. Catharines, August 27, 1991.

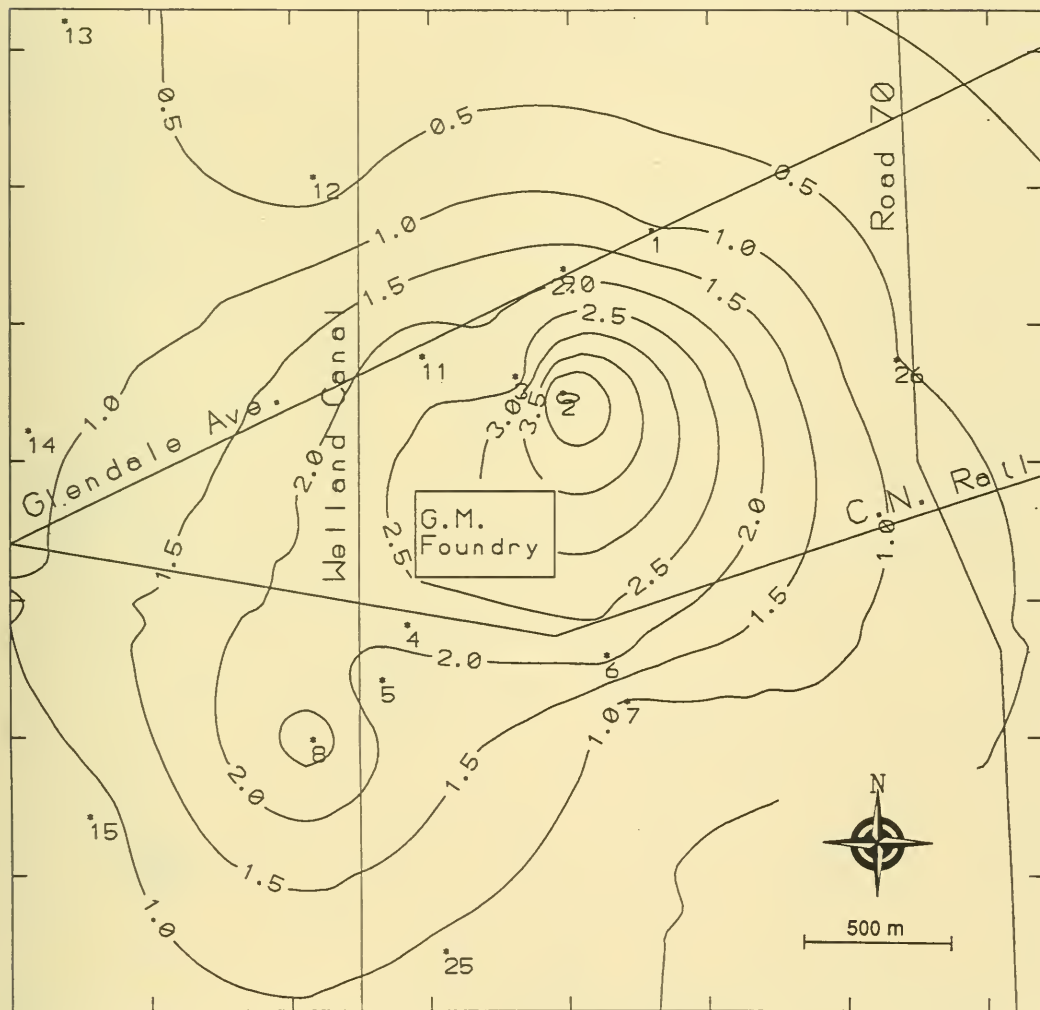


Figure 5: Contour Map of Aluminum Concentrations ($\mu\text{g/g}$) in Maple Foliage in the Vicinity of the G.M. Foundry, St. Catharines, August 27, 1991.

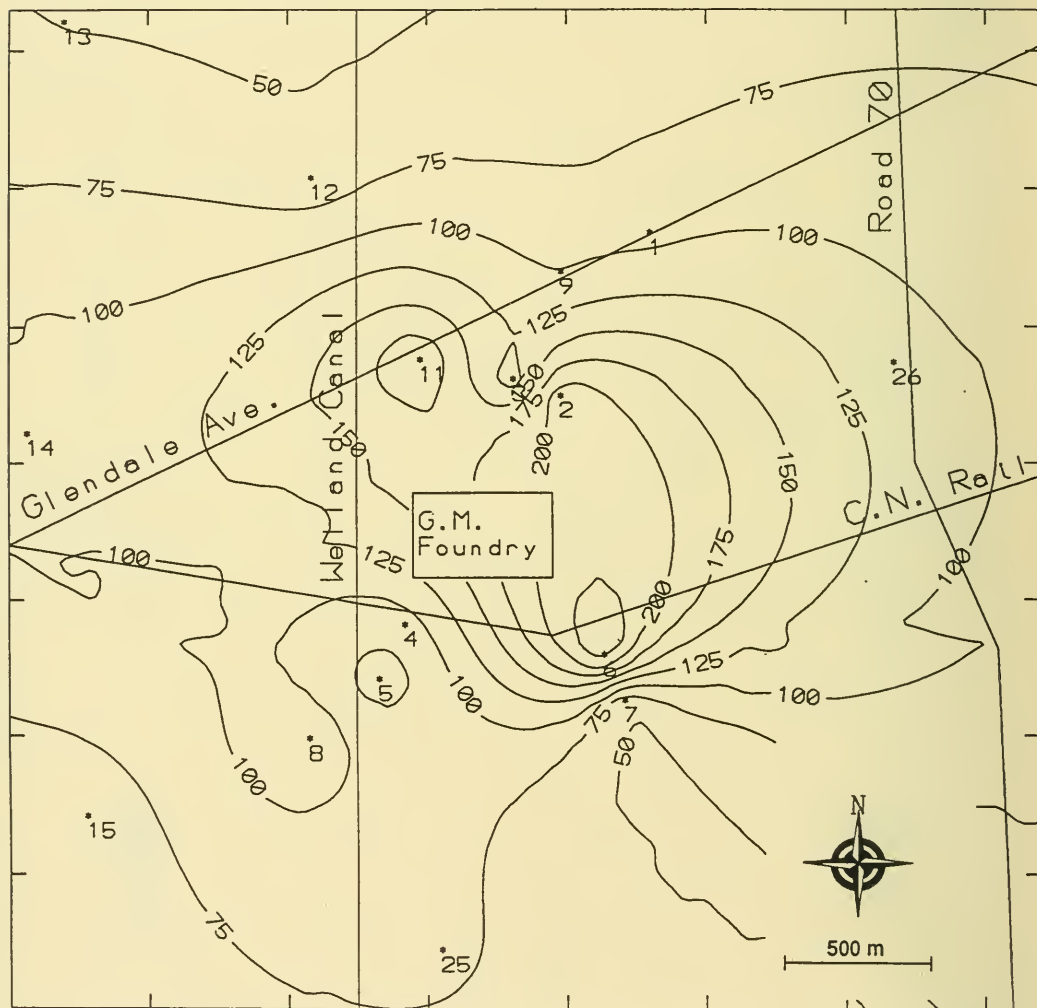


Figure 6: Contour Map of Manganese Concentrations (ug/g) in Maple Foliage in the Vicinity of the G.M. Foundry, St. Catharines, August 27, 1991.

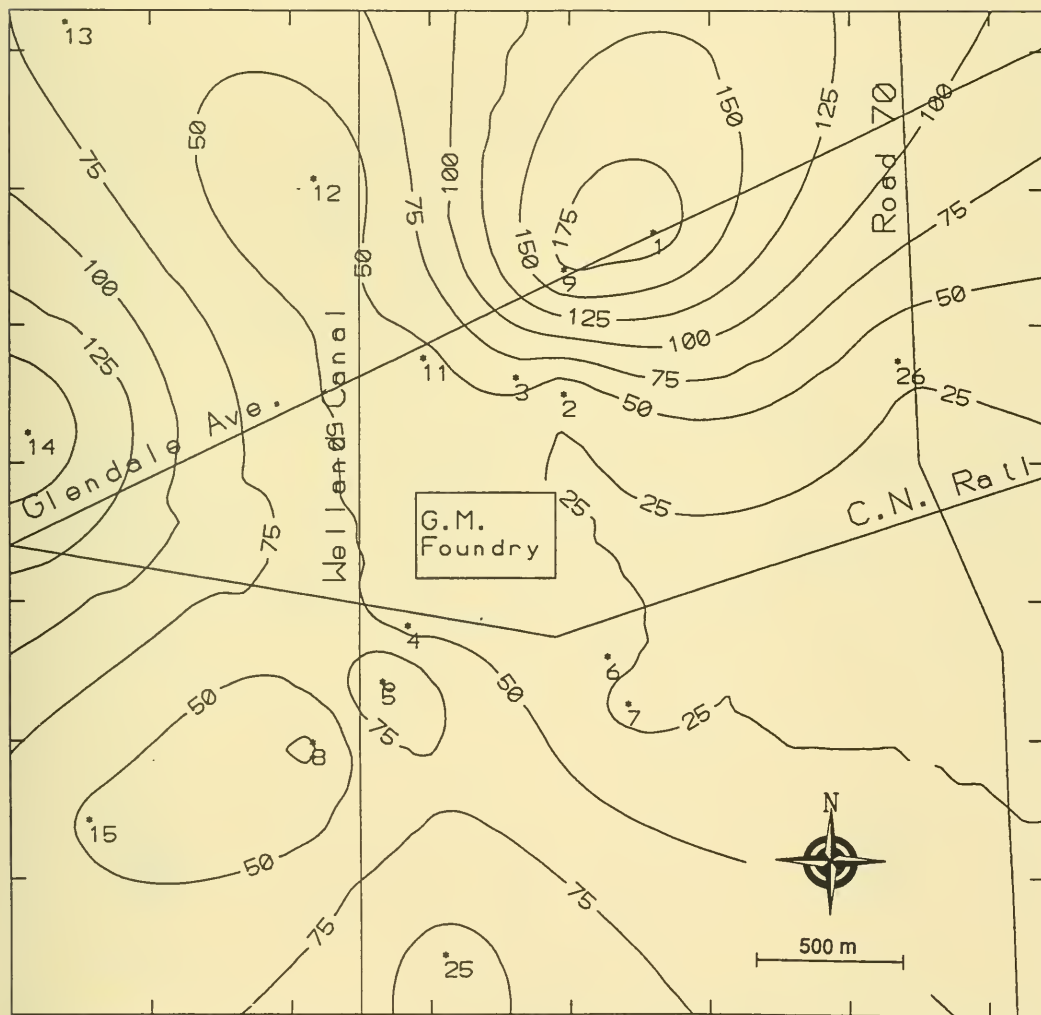


Figure 7: Contour Map of Average Monthly (31 day exposure) Iron Concentrations (ug/g) in Moss Bags in the Vicinity of the G.M. Foundry, St. Catharines, May to October, 1991.

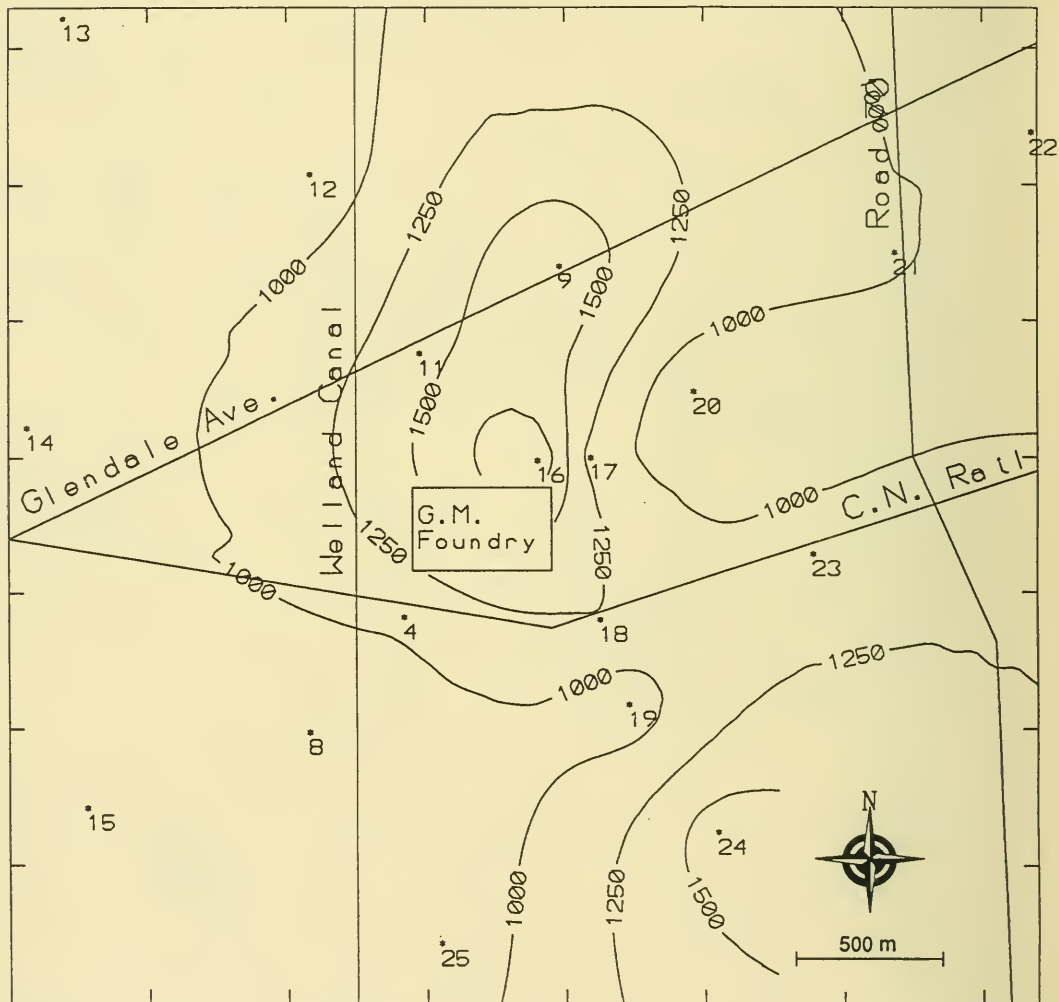


Figure 8: Contour Map of Average Monthly (31 day exposure) Fluoride Concentrations (ug/g) in Moss Bags in the Vicinity of the G.M. Foundry, St. Catharines, May to October, 1991.

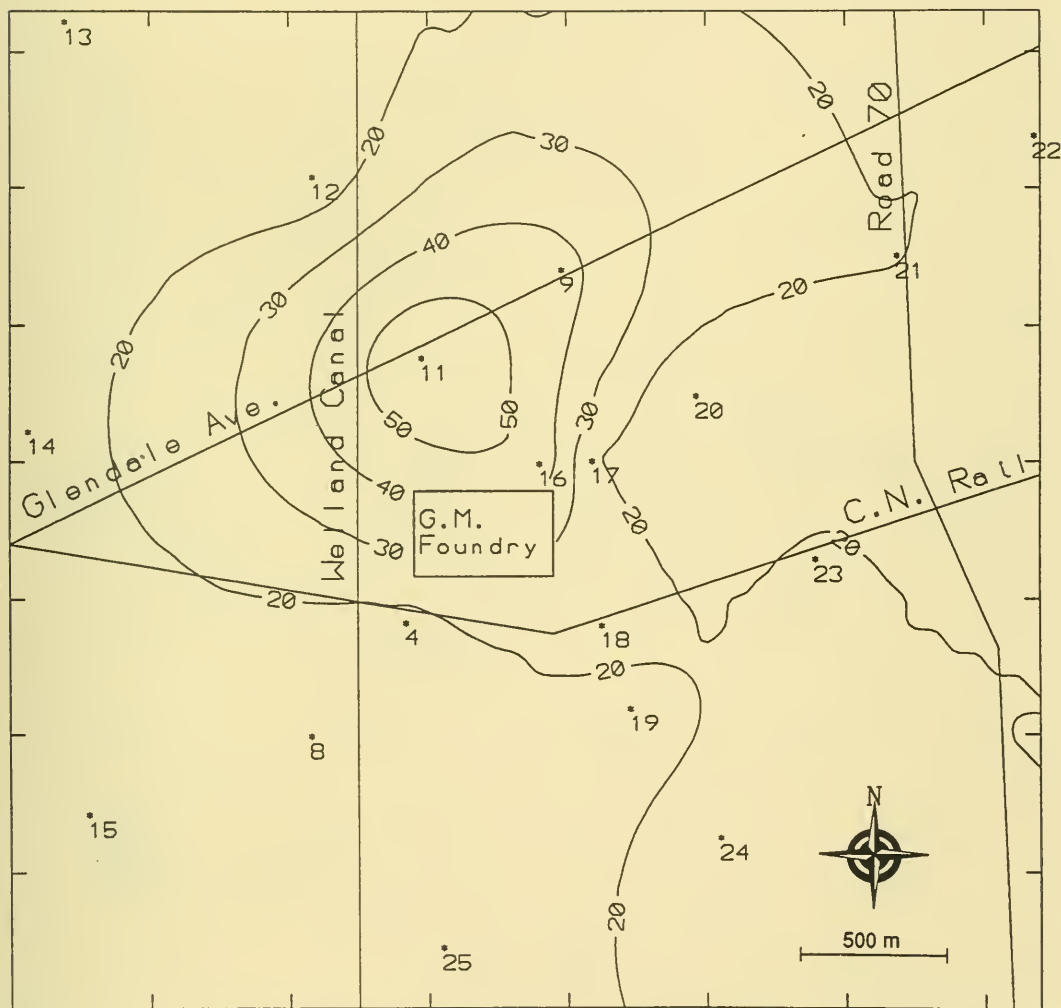


Figure 9: Contour Map of Average Monthly (31 day exposure) Selenium Concentrations (ug/g) in Moss Bags in the Vicinity of the G.M. Foundry, St. Catharines, May to October, 1991.

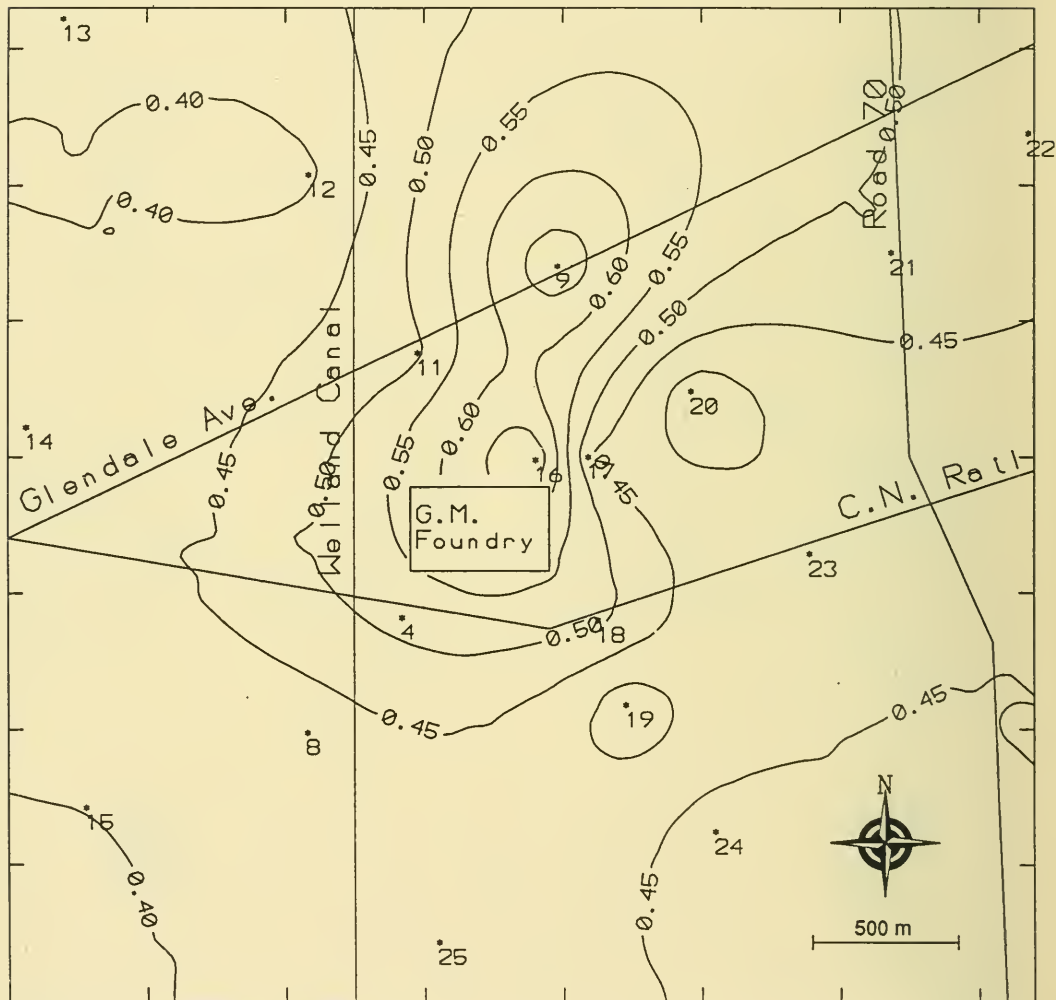


Figure 10: Contour Map of Average Monthly (31 day exposure) Lead Concentrations (ug/g) in Moss Bags in the Vicinity of the G.M. Foundry, St. Catharines, May to October, 1991.



Figure 11: Contour Map of Average Monthly (31 day exposure) Aluminum Concentrations (ug/g) in Moss Bags in the Vicinity of the G.M. Foundry, St. Catharines, May to October, 1991.

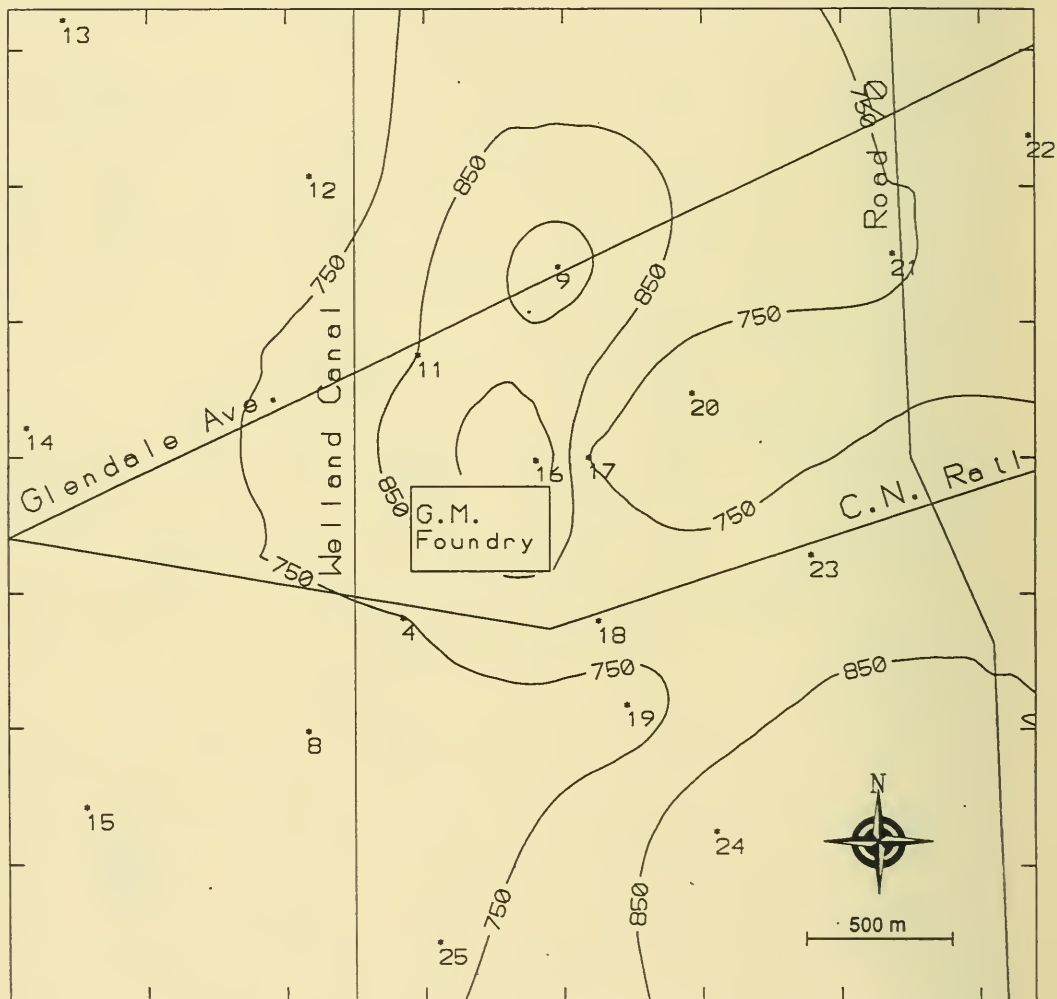


Figure 12: Contour Map of Average Monthly (31 day exposure) Manganese Concentrations (ug/g) in Moss Bags in the Vicinity of the G.M. Foundry, St. Catharines, May to October, 1991.



